I – Problem Statement Title (STAP 096)

Pre-cast Bridge Pier Columns with Energy Dissipating Joints

II – Research Problem Statement

Question: Can we develop a segmentally precast bridge pier column that could compete with cast-in-place columns in terms of initial cost, stiffness, strength, ductility, and durability while offering improvements on post-extreme event functionality and repair costs?

New materials and construction techniques allow engineers to tailor structural response to extreme load events with greater effectiveness. Through the innovative application of FRP composites, post-tensioning, high performance concrete, and/or replaceable plates that may serve as energy dissipating elements, the usually troublesome segmental construction of bridge columns may be exploited to improve seismic performance and reduce post-event repair costs. Successful development of this system could address several of the STAP roadmap outcomes and render benefits in terms of public safety, life-cycle infrastructure costs, and traffic impacts.

III – Objective

STAP Roadmap Outcome:
#8. Improved performance of bridges and highway structures to earthquakes and other man-made and natural extreme events, and improved ability to quickly restore facilities to full functionality

Segmentally precast columns may be designed to exhibit very small post-event residual deflections, potentially allowing bridges to remain in service for immediate emergency needs. If performing as envisioned, quick and simple replacement of yielded external reinforcement plates could return the bridge to full functionality with relatively little expense. Such repair will not require even temporary closure of the bridges.

#4. Optimized and validated new and/or existing materials, systems and components for bridges and highway structures

Input regarding construction details should be sought from contractors and precasters early in the project to address fabrication and assembly issues. Structural performance of the column system should then be investigated through both large-scale experiments and numerical simulation. Alternative detailing to expedite construction and address corrosion concerns should be investigated as part of the experimental program. Repair and retesting of each specimen should be conducted to gather data on repair effectiveness and facilitate post-event modeling. Using the validated analysis model, a suitable parametric study should be conducted to explore the influence of different design parameters.

#3. Reduce the impact of structure construction and maintenance activities on the traveling public

If effectively designed and built, precast substructure systems could offer significant reductions in construction time.

IV – Background

Recent experimental and theoretical studies have demonstrated promising performance of segmented precast columns employing combinations of prestressing and mild steel reinforcement. Experimental results on ½ scale piers indicated construction joint performance to be a key factor. The addition of innovative connections employing FRP's, high performance concrete and energy dissipating details could significantly advance the state-of-art in this growing field.

V – Statement of Urgency, Benefits, and Expected Return on Investment

Successful development of this technology could offer cost savings from accelerated construction (minimal traffic delays, improved jobsite safety, and reduced environmental impacts). Life cycle costs of piers could be cut through reduced repair expenses. Most importantly, improved structural performance with minor residual deformations will contribute to public safety by allowing bridges to remain open for emergency services after an extreme event. Any one of these advantages warrants this system for further investigation.

VI – Related Research

- Hieber, D.G., J.M. Wacker, M.O. Eberhard, and J.F. Stanton. *State-of-the-Art Report on Precast Concrete Systems for Rapid Construction of Bridges*. Washington State Department of Transportation Technical Report # WA-RD 594.1, Mar. 2005.
- Rouse, J.M. *Behavior of Bridge Piers with Ductile Fiber Reinforced Hinge Regions and Vertical, Unbonded Post-Tensioning*. Doctoral Thesis, Cornell University, 2004.
- Priestley, M.J.N., S. Sritharan, J.R. Conley, and S. Pampanin. Preliminary Results and Conclusions from the PRESSS Five-Story Precast Concrete Test Building, *PCI Journal*, Vol. 44, No. 6, Nov. 1999, pp. 42-67.

- Kwan, W.P. and S.L. Billington. Unbonded Post-tensioned Bridge Piers: Part I - Monotonic and Cyclic Analyses, *ASCE J. Bridge Engr.*, Vol. 8, No. 2, March/April 2003, pp. 92-101.
- Kwan, W.P. and S.L. Billington. Unbonded Post-tensioned Bridge Piers: Part II - Seismic Analyses, *ASCE J. Bridge Engr.*, Vol. 8, No. 2, March/April 2003, pp. 102-111.
- Kesner, K.E. *Development of Seismic Strengthening and Retrofit Strategies for Critical Facilities Using Engineered Cementitious Composite Materials.* Doctoral Thesis, Cornell University, 2003. (Includes results of laboratory testing of bolted connections of precast members.)

VII – Deployment Potential

This research should yield specific recommendations for design approach, material specifications, and construction details for implementation of a prototype pier. A set of damage metrics along with corresponding recommendations for addressing post-event use and repair procedures should be included in the report.